

Attachment A

An Analysis of Digital Must Carry and the Adoption of Digital Receivers

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I. Introduction and Summary

A. My background

My name is Gregory L. Rosston. I am Deputy Director of the Stanford Institute for Economic Policy Research at Stanford University. I am also a Lecturer in the Economics Department at Stanford University. I received my Ph.D. and M.A. in economics from Stanford University, and my A.B. with honors in economics from the University of California, Berkeley. My specialties in economics are industrial organization and regulation with an emphasis on telecommunications. I served at the Federal Communications Commission (“Commission” or “FCC”) for three and one-half years as the Deputy Chief Economist of the Commission, as the Acting Chief Economist of the Common Carrier Bureau and as a senior economist in the Office of Plans and Policy. In these positions, I had significant involvement with the Commission’s spectrum policy, auctions, and competition issues in all areas under the Commission’s purview. I have been the author or co-author of a number of articles relating to telecommunications competition policy and spectrum policy, including an FCC staff working paper on

spectrum policy. My Ph.D. dissertation studied the effects of FCC policy on the land mobile radio industry. I have also co-edited two books on telecommunications. A copy of my vita is attached as Exhibit A.

B. Scope and Summary of my analysis

In its Further Notice of Proposed Rulemaking on the Carriage of Digital Broadcast Signals, the Commission asks "...how the resolution of the carriage issues would impact the digital transition process."¹ In response to this question, the National Association of Broadcasters (NAB) submitted a scenario analysis ("Scenario Analysis") that concluded mandating digital must carry would accelerate the digital transition by 10 years or more.² The National Cable & Telecommunications Association (NCTA) has asked me to evaluate this submission.

The Scenario Analysis claims that without digital must carry, the transition would not be complete until 2020 or beyond, but that enactment of a digital must carry requirement would accelerate the transition possibly by 10 years or more. The Scenario Analysis then concludes that digital must carry is "mandatory" to accelerate the transition.

The Scenario Analysis contains some important facts about the industry, but its conclusion depends on many implicit and unsupported assumptions, assumptions that in some cases the evidence directly contradicts. For example, the Scenario Analysis assumes that if digital signals of marginal stations are carried by cable systems, cable

¹ Carriage of Digital Television Stations, 58 Fed. Reg. 16524 (Mar. 26, 2001) ("First Report and Order" and "Further Notice.") at ¶ 3.

² "Implications of the Adoption of Digital Must Carry on the Speed of the Broadcast DTV Transition: A Scenario Analysis," Kraemer, J. and Levine, R., June 11, 2001.

subscribers will have increased incentives to purchase digital sets. But there will be no such incentives unless the broadcasters that rely on must carry use their digital signals to provide something different from the standard definition programming that is already available in large quantity to cable subscribers. Yet there is no evidence that these broadcasters are or will be using their digital channels to provide high definition programming. This is just one example of the lack of evidence supporting the assumptions underlying the NAB Scenario Analysis.

In my evaluation, I highlight the issues that underlie the assumptions of the Scenario Analysis, and show the absence of evidence supporting the NAB's conclusions. In addition, the NAB's Scenario Analysis combines the effects of six different legislative and regulatory proposals so that it fails to demonstrate that a digital must carry rule would have any effect in accelerating the transition at all, much less accelerating it by ten years or more. In short, the Scenario Analysis provides no predictive value about the effect of a digital must carry rule. It simply speculates how the digital television market might evolve in one narrow set of possible, but unlikely, circumstances.

II. Evaluation of NAB's Scenario Analysis

In my evaluation, I point out what assumptions are required for the Scenario Analysis and assess the likelihood of those assumptions holding. In addition, the authors co-mingle six different legislative and regulatory changes including the must carry requirement. This means that even if one believes all of the assumptions necessary to support the story, they have failed to demonstrate any effect of digital must carry – the other five effects could account for the accelerated adoption.

In concluding that digital must carry will significantly accelerate the transition to digital broadcasting, the authors seem to assume that the following six step scenario will unfold:

1. Digital signals over cable will be more attractive to cable households than the same signal over-the-air.
2. Inclusion of over-the-air signals that would otherwise not be carried would cause more cable subscribers to buy digital receivers
3. Because more cable subscribers buy digital receivers, they will be cheaper for over-the-air households
4. Because more cable households have digital receivers, content on over-the-air stations will improve
5. The decrease in price and increase in over-the-air quality will be sufficient to cause many more over-the-air households to acquire digital receivers more rapidly
6. The FCC, Congress and the administration will turn off analog stations when the 85% threshold is reached

Based on the available evidence, there is no reason to believe that all six steps would be met. Accordingly, the Scenario Analysis fails to demonstrate the claimed effect of digital must carry. To show this, I evaluate each step to assess the underlying assumptions.

A. Digital cable vs. over-the-air digital signals

The first step involves the idea that digital signals over cable are more attractive than over-the-air digital signals to cable subscribers. The reason this step is included in the argument is because if digital over-the-air reception were as attractive to cable subscribers as viewing the signals over their cable, then there would be no need for over-the-air stations to be carried on cable at all.

Given the experience to date, cable subscribers seem to watch much more of all programs via their cable and more of their viewing of local over-the-air stations is done through the cable system. This occurs in a regime where virtually all local channels are carried on the cable system. There may be some difference in the quality of digital

reception from a cable system compared to over the air because of the difference in encoding (VSB vs. QAM), and there is greater ease in viewing the cable version of a broadcast signal, even if the signal is available over-the-air. The logic of this step in the argument appears to hold: cable subscribers are more likely to watch over the cable system.

B. Will the addition of digital over-the-air signals that would otherwise not be carried lead to more cable subscribers buying digital receivers?

The second step of the NAB argument is that if more local over-the-air digital signals are on the cable system, more cable subscribers will buy digital receivers. This step requires two assumptions. First, it requires that the local over-the-air stations that would otherwise not be carried be more attractive than the cable programming they replace. The second assumption required for this step is that these marginal over-the-air channels would have a significant effect on the digital receiver purchase decisions of cable households.

Because cable programmers and over-the air stations are both able to provide digital and high definition content, the question of how content will affect digital adoption depends on the relative quality of the different programs. It is important to analyze the quality of the marginal stations (i.e., those stations that would not be carried by a cable system in the absence of a digital must carry rule). It is those marginal stations those that will be competing for scarce space on the cable system.

For digital must carry to increase the adoption of digital receivers in cable households, those stations that would not otherwise be carried would have to provide some reason for cable subscribers to buy digital television sets when they otherwise would not. Carriage of an additional over-the-air digital signal is likely to reduce cable

programming on a one-for-one basis (or more if the replaced cable channels would otherwise have provided analog programming). If the replaced cable programming were also digital and more attractive to cable subscribers than the must carry station, then must carry actually could reduce the adoption of digital receivers.³

Even if the must carry digital stations that would not otherwise be carried were more attractive than the cable programming they replaced, it is unlikely to make much of a difference in the adoption of digital receivers and the Scenario Analysis does not show that it would make any difference.⁴ For example, everyone who would adopt a digital receiver might make the decision based on the availability of digital pay-per-view movies (or other digital signals unaffected by digital must carry) and not care about marginal over-the-air stations. There may be others who would not pay the cost of a new digital receiver regardless of the amount of digital offerings as long as they have analog offerings available. In both of these cases, the marginal stations would have no effect. However, for the Scenario Analysis to hold, marginal stations would have to make a large difference in the digital receiver adoption rate of cable subscribers.

³ Chitty reviews the efficiency and competitive incentives created by vertical integration and finds that vertical integration causes increased efficiency and overall social welfare gains. Because of the efficiencies, according to the Chitty logic, allowing cable operators to choose programming, including digital, could increase the rate of digital receiver adoption because the cable operator/programmer may better be able to internalize the effects of customer preferences. In this case, if consumers want high quality digital programming the vertically integrated cable programmer might better be able to satisfy this demand than an arm's length regulated relationship between a cable operator and a set of independent broadcasters. Chitty, T., "Vertical Integration, Market Foreclosure and Consumer Welfare in the Cable Television Industry," *American Economic Review*, June 2001, 428-453

⁴ The NAB Scenario Analysis makes the argument that cable programmers have an incentive to preclude even higher quality over-the-air stations because of advertising revenue. However, with the small number of digital receivers, advertising revenue on marginal over-the-air digital stations will be small for the foreseeable future so the competition effect should be small as well.

The over-the-air stations that would not otherwise be carried in digital will also be carried during the transition in analog format. As a result, for digital must carry to increase the adoption rate substantially:

- i) there would have to be a large quality difference between the analog and digital programming;
- ii) the quality difference on marginal stations (that are not attractive enough for a cable system to carry at a price of zero) would have to be substantial; and
- iii) the substantial quality difference on these marginal stations alone would have to be the key factor in the adoption decision of a large number of customers.

The three pieces underscore the necessary assumptions to conclude that digital must carry would make a substantial difference in the adoption rates of cable subscribers. While economists are frequently concerned with marginal effects, the Scenario Analysis is concerned with a large shift in consumer adoption. The Scenario Analysis requires that the large shift in adoption be driven by quality differences on marginal stations but provides no evidence to support these three essential pieces for this step of the analysis to hold.

The argument that marginal stations would have a substantial impact on adoption faces hurdles regardless of whether they broadcast multicast standard definition signals or provide high definition programming. Adoption rates for new technology vary greatly and depend on a number of factors. One of the major factors influencing the adoption of a new technology is the improvement over the currently available technology. If a new

technology does not offer a significant improvement over the existing technology, consumers will be slower to adopt the new technology.⁵

The arguably significant improvement in this case is HDTV signals (as opposed to standard definition digital or analog signals). Yet the evidence shows a very limited amount of broadcast HDTV programming, and there is no evidence or representation that broadcasters will choose to provide a substantial amount of HDTV programming in the future. Standard definition digital signals of must-carry stations are unlikely to provide substantial benefit to cable consumers relative to current signals. They are merely duplicative in picture quality and may, in many cases, merely simulcast the content of the analog signals that are already being carried. Even if broadcasters provided standard definition programming that was different from the programming on their analog channels, cable customers already have access to a large number of standard definition program choices. As a result, cable customers may not see substantial advantage to acquiring a digital receiver for standard definition broadcast signals.

This is especially true to the extent broadcasters are simulcasting the same programming on their analog and digital channels. With simulcasting, the difference in product on analog and digital channels will primarily be due to the high definition picture quality (and possibly additional features).

The Scenario Analysis provides no evidence about the extent to which the availability of high definition programming will cause cable subscribers to buy new digital sets, much less the effect of high definition programming on marginal channels.

⁵ For example, cable adoption increased more rapidly when cable systems began to add multiple choices not available on local over-the-air stations. Crandall, R. and Furchgott-Roth, H. Cable TV: Regulation or Competition, Ch 1.

Nor is there any evidence about the extent to which broadcasters will choose to provide high definition programming, much less the extent to which marginal broadcasters will choose to do so. In the absence of such data, there is no basis for assuming that a dual carriage requirement will cause any cable subscribers to purchase digital receivers.

In order for the NAB virtuous circle story to hold, mandatory carriage would have to cause many more subscribers to buy digital television receivers to watch digital content from marginal stations when they can watch the analog feed from these stations without a purchase. There is no evidence that forcing carriage of over-the-air stations – stations that would not be carried voluntarily even if the price were zero – will increase adoption of digital receivers by cable subscribers. While this is sufficient to reject the conclusions of the Scenario Analysis, I continue to assess the remaining steps.

C. Will increased adoption of digital receivers by cable subscribers lead to lower receiver prices for over-the-air households?

The third step of the argument is that if substantially more cable subscribers were to buy sets (assuming the first two steps hold), then digital sets for over-the-air viewing would be cheaper. The reduction in price depends greatly on the economics of the industry and the price of the receiver sets. It does not seem like a big leap to assume that if more digital sets were sold, they would be cheaper. An important question, however, is the magnitude of the price difference. For the Scenario Analysis story to hold, the price decline resulting just from digital must carry would have to be sufficient to cause many more sets to be sold. In all likelihood, this would have to be a large price difference. There is no evidence that a large price difference would result from imposition of digital must carry.

Even if more cable customers were to buy digital sets and reduce the prices of cable digital receivers, this might not reduce substantially the price for digital over-the-air receivers (i.e. digital receivers with over-the-air tuners). If technology for receiving and viewing digital signals on cable system, such as QAM decoders, does not feed back into receiver prices for over-the-air reception that requires VSB decoders, then increased adoption by cable subscribers might have little or no effect on the prices for over-the-air digital receivers.

D. Will higher adoption of digital receivers by cable subscribers lead to more attractive digital over-the-air programming?

The fourth step is that, because of must carry and increased access to households that have digital receivers, over-the-air broadcasters would increase the attractiveness of their digital programming relative to analog. It is important to recognize that the appropriate benchmark is what the over-the-air attractiveness would be without a digital must carry requirement. There are two dimensions to increasing the over-the-air attractiveness of digital over-the-air programming – quantity and quality.

The first possibility is that digital must carry would increase the quantity of digital programming. The Commission has mandated digital transmission by 2002. Some stations are already providing some digital service. Others will begin over the next couple of years. Some stations may request a waiver of the deadlines to begin digital broadcasting.

The increase in the quantity of over-the-air digital programming that the Scenario Analysis states would occur to spur sales of digital receivers would have to come from a

reduction in the number of waivers and/or more digital programming.⁶ These increases would have to come on stations that would not have been carried absent a digital must carry rule. This increase would have to come even given the deadlines for digital transmission and the simulcast rules. The Scenario Analysis does not differentiate between stations that would and would not be carried in the absence of a digital must carry rule.

The second possible way to increase attractiveness of digital over-the-air programming is to increase program quality. If there are no requirements for a cable system to air a particular channel, then broadcast programmers have to compete with all other potential program services to get on the system. Competition to get on cable systems will generally take place in two dimensions – price and quality. In the absence of a digital must carry requirement, local over-the-air broadcasters might improve the quality of their digital offerings or reduce price to the system operator to get on the system.⁷

With a digital must carry rule, it is possible that local over-the-air stations will have a reduced incentive to invest in the quality of their digital programming, contrary to the Scenario Analysis. These stations will still have an incentive to attract an audience for advertisers. But they will not have the need to convince the cable operator to carry their signal. If local over-the-air broadcasters respond to this incentive and provide a lower quality digital product under digital must carry, then consumers might reduce their

⁶ A different way to ensure that stations do not delay their digital over-the-air feeds would be to issue a clear statement that the Commission does not intend to grant waivers and to stick by that statement.

⁷ Since the price with must carry is zero, some might have to pay to get on the system or provide additional programming as a way to reduce price below zero.

demand for digital receivers. This analysis simply shows that even assessing the direction of the effect from digital must carry is not straightforward and the Scenario Analysis has failed to show that digital must carry will result in increased attractiveness of over-the-air signals, a necessary condition for its conclusion to hold.

E. Will lower receiver prices and higher programming quality induce a large number of over-the-air households to adopt digital receivers?

The next step of the NAB's scenario is that lower receiver costs and higher programming quality would cause more over-the-air households to buy digital receivers and speed the transition. This step requires that the price decrease in digital sets and the increase in program quality be sufficient to cause a large number of households who currently do not subscribe to MVPD service to speed up their purchase of digital receivers.

With national cable penetration at 68%, there would still need to be an additional 17% of TV households equipped to receive digital broadcast signals.⁸ More than half the remaining 32% of television households would either have to get dual signals from another MVPD, such as DBS, or would have to buy digital receivers or digital-to-analog converters in order to reach the 85% threshold.⁹ As NAB has noted, over 20% of all television households nationwide are broadcast-only homes.¹⁰ Until a majority of these broadcast only households buy digital receiver equipment, the transition will not end.

⁸ Seventh Annual Report In the Matter of Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming CS Docket No. 00-132, released January 8, 2001, Table B-1.

⁹ Note that this number will vary greatly depending on the specific geographic area.

¹⁰ NAB Comments, CS Docket No. 01-129, filed Aug. 3, 2001, p 2.

However, there is no evidence to support the key assumption for this step of the Scenario Analysis – that over-the-air households will have a sufficiently high price elasticity of demand and response to quality change to increase the adoption rate of digital receivers. High definition over-the-air broadcasts are likely to be simulcast in analog format so over-the-air consumers will still have access to program content, albeit in a different form, without purchasing a digital receiver. Over-the-air households will also, by definition, have access to analog stations until the end of the transition as well so that they will have an alternative to purchasing digital receivers.

Moreover, these over-the-air households currently do not pay for their television signals, and presumably place a low value on receiving high quality signals or a large choice of viewing options.¹¹ Today, these households do not choose MVPD service from cable or satellite (which includes about 40 or more channels on expanded basic lineups), so digital multicast is unlikely to be sufficiently attractive to cause them to purchase a new digital receiver. The Scenario Analysis fails to demonstrate any willingness or ability of such consumers to spend money on a higher quality signal or additional viewing options. These viewers may also be reluctant to spend extra money to receive a higher quality picture of the same programming. To conclude that digital must carry is important to entice low-value customers to buy a digital receiver, one would have to believe that increased adoption by cable subscribers would bring the price of receivers down. But it is probably the case that for the low-value households the price would have to come down substantially more than it would without digital must carry, not just

¹¹ “Completing the Transition to Digital Television,” Congressional Budget Office, September 1999, p viii. There are various reasons why these people do not pay for their television, including placing a low value on television and having low-income.

marginally more. The Scenario Analysis presents no evidence that price changes of any likely magnitude will lead to the massive change in adoption needed to support their conclusion.

The Scenario Analysis predicts the behavior of over-the-air households in the next 10 to 20 years without any evidence on their purchase plans. While current data indicate that *all* consumers are likely to be slow in their adoption of digital technology, over-the-air households are likely to be even slower adopters regardless of a digital must carry requirement. The Scenario Analysis predicts that digital must carry will increase adoption rates of all groups substantially. However, the Scenario Analysis does not provide any indication of the price decline (or quality increase) so that even if one knew the price elasticity of demand (or quality elasticity) for the over-the-air households, one could not predict the change in adoption.

With the analysis above, any price decline and quality increases due to digital must carry are speculative at best; thus the conclusion of massive changes in buying habits for reluctant consumers has no foundation.

F. Will the 85% threshold be meaningful?

A point related to the Scenario Analysis is whether the Commission thinks that 85% is a real threshold. The NAB report states “It is doubtful that the public policy process would force analog turn off after achieving the bare minimum 85% of households digital capable.”¹²

¹² “Implications of the Adoption of Digital Must Carry on the Speed of the Broadcast DTV Transition: A Scenario Analysis,” Kraemer, J. and Levine, R., June 11, 2001, p 22.

If 85% is not the real threshold, then making conclusions about reaching 85% is of questionable use even though that is the sixth necessary step of the analysis. For example, if the public policy process would require 95% digital adoption, that will take much longer to reach and may require other mechanisms.

The NAB claims that over 41% of all television households have at least one broadcast-only set.¹³ This calls into question whether, even if the 85% threshold could somehow be met because of the availability of digital signals to cable subscribers, it will be politically feasible to terminate the transition at that time and disable all sets not equipped to receive digital signals over-the-air or via cable. And, significantly, the Consumer Electronics Association's projection of set purchases suggests that consumers appear reluctant to purchase digital television sets.¹⁴

Also, even if 85% is the real threshold, it will be much easier to reach in certain areas than in others. The threshold will be reached on a market-by-market basis, but the benefits from the transition -- reallocation of the spectrum and the rosy feedback effects are likely only to be realized when a substantial majority of the population is in areas that have adopted digital receivers and turned off analog broadcasts.

For example, cable penetration varies widely, even in the top cities.¹⁵ With such different penetration rates, meeting any threshold will vary greatly. The Scenario

¹³ NAB Comments, CS Docket No. 01-129, filed Aug. 3, 2001, p 2.

¹⁴ In July 2001, only 39% of consumers said that their next television set would be digital; 50% said that it would not be. CEA Market Research – Consumer Perspectives of Digital TV II – Summary, July 24, 2001, p 6.

¹⁵ CBO reports that as of 1996, the cable penetration was below 52% in Dallas/Ft. Worth and almost 77% in Boston. “Completing the Transition to Digital Television,” Congressional Budget Office, September 1999, Table 2.

Analysis attempts to examine the effects of a digital must carry rule on a nationwide basis when it is probably more important for the evaluation of benefits to understand when the threshold will be met in each area. The realization of benefits may be contingent on transition in certain cities that are slower than the nationwide average and have less responsiveness to added digital must carry signals.

G. Too many factors change in the Scenario Analysis to conclude anything about digital must carry.

Figure 7 of the report, “Broadcast DTV Accelerated Rollout Scenario” has a column “Legislation and Regulation” that makes assumptions about what will occur. While this proceeding is specifically about digital must carry, and the conclusions of the report focus on digital must carry, the figure includes six factors that differ from the baseline (Figure 5):

1. The FCC adopts DTV as a critical issue
2. FCC resolves cable must-carry (i.e., cable must carry free-to-air DTV signals up to capacity limits)
3. Proactive FCC mandates all channel receivers as of date certain (e.g., Jan 1, 2004) for sets 13” and larger.
4. FCC resolves all set to box technical issues, including copy protection.
5. Congress recognizes difficulty of shutting off analog in 2006 but makes it a policy priority to achieve turn off no later than Dec. 31, 2010; FCC instructed to facilitate so as to move ahead with next generation wireless networks.
6. Government continues pressure for auctions; channels 60-69 auctions occur no sooner than the schedule set out in the 2002 Budget; similar process with channels 52-59.¹⁶

¹⁶ “Implications of the Adoption of Digital Must Carry on the Speed of the Broadcast DTV Transition: A Scenario Analysis,” Kraemer, J. and Levine, R., June 11, 2001, Figure 7.

These other changes (e.g. mandating all channel receivers) could account for much more of the effect than the digital must carry requirement. Moreover, these other changes do not require digital must carry to be implemented.

I have not analyzed the effect of the other proposed changes that are part of the accelerated scenario analysis. But their inclusion points out that other factors are important in the adoption of digital receivers. Even in the scenario analysis, if one believes all of the assumptions necessary, the inclusion of other changing factors make it impossible to conclude that a digital must carry rule would have any effect, much less be the most significant factor.

III. Conclusion

Carefully evaluating the Scenario Analysis on a step-by-step basis shows the underlying assumptions necessary. I briefly summarize the results of this analysis.

<u>Step Required</u>	<u>Conclusion</u>
1. Digital signals over cable are more attractive to cable households than the same signal over-the-air.	This step appears to hold.
2. Inclusion of over-the-air signals that would otherwise not be carried would cause more cable subscribers to buy digital receivers	There is no evidence to support this. It might go the other way. It is very hard to believe this would have a substantial effect – especially if must-carry broadcasters use their digital signals to provide standard definition television of the type that is already available in large quantity to cable customers.
3. Because more cable subscribers buy digital receivers, they will be cheaper for over-the-air households	If the premise holds, it is likely. But the study fails to show the difference in the magnitude of price decline is sufficient to cause the massive change in adoption.
4. Because more cable households have digital receivers, content on over-the-air stations will improve	It is unclear what will happen to the quality of over-the-air stations. Depending on the incentives, quality may decrease.
5. The decrease in price and increase in over-the-air quality will be sufficient to cause many more over-the-air households to acquire digital receivers more rapidly	There is no evidence to support the large increase necessary for the Scenario Analysis conclusion to hold.
6. The FCC, Congress and the administration will turn off analog stations when the 85% threshold is reached	The uncertainty of the threshold and the differences across geographic areas makes this uncertain.

Only one of the six steps is supportable enough to satisfy the story. A second factor, the price decline may hold, but there is no evidence supporting the magnitude necessary to support the scenario analysis.

Even accepting all six steps in the Scenario Analysis is not sufficient to conclude that digital must carry will lead to the change in adoption put forth in the Scenario Analysis. Further, it is impossible to see how the Scenario Analysis arrived at a 10 year difference in adoption because they present no calculations. Finally, the scenarios differed by six factors rather than by holding everything except for digital must carry constant, further invalidating the conclusion.

Exhibit A

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“The Digital Divide: Definitions, Measurement, and Policy Issues,” in Bridging the Digital Divide, California Council on Science and Technology, May 2001 (with Noll, R., Older-Aguilar, D. and Ross, R.)

Other Professional Activities

Referee for *American Economic Review*, *Rand Journal of Economics*, *Industrial and Corporate Change*, *Journal of Industrial Economics*, *Telecommunication Systems*, *Journal of Economics and Management Science*.

FCC Economist Panel Hearing on the Economics of Interconnection, May, 1996.
FCC Economist Panel Hearing on the Economics of RBOC Entry under Section 271, July, 1996.

FCC Economist Panel Hearing on Competitive Bidding for Universal Service Provision, March, 1997.

Consultant for the World Bank, 1998.

FCC Academic Expert Panel on “A New FCC for the 21st Century,” June 1999.

FCC Academic Expert Panel on AT&T—MediaOne Merger, February, 2000.

Awards

Chairman's Distinguished Service Award, FCC, 1997.

University of California, Brad King Award for Young Alumni Service, 1994.

National Performance Review Hammer Award for Reinventing Government, 1994.

Telecommunications Policy Research Conference Graduate Student Paper Competition, 2nd Place, 1994.

John M. Olin Foundation Fellowship, 1989-1990.

Charles Mills Gayley Fellowship, 1985.

Stanford University Fellowship, 1984-1985.